



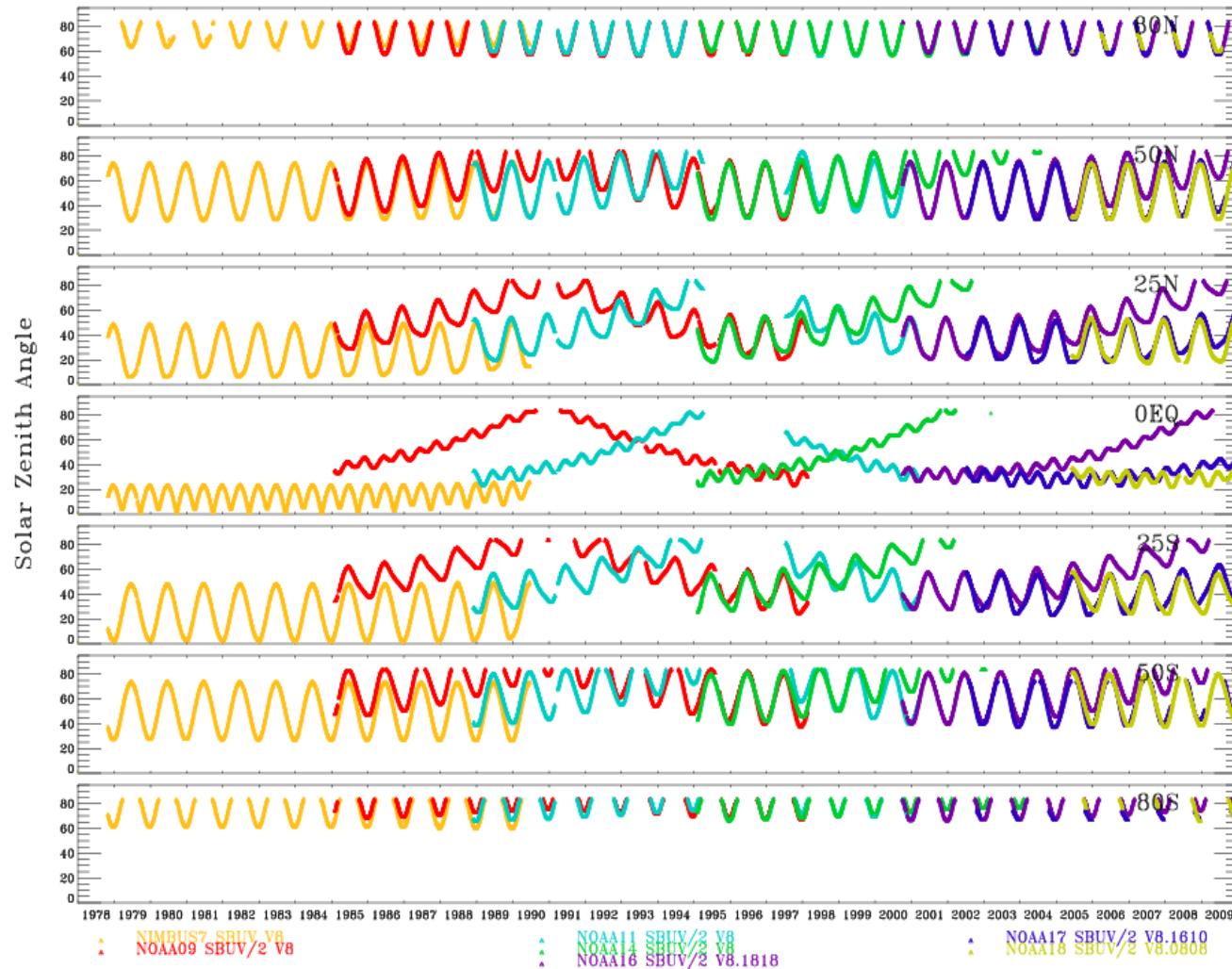
The Trend of Ozone Profile from SBUV(/2) from 1978 to 2009

Shi-Keng Yang (SKY), Jeannette Wild, and Craig Long
NOAA/Climate Prediction Center

CERES Science Team Meeting

Newport News, 4/27/2011

Solar Zenith Angles of NOAA Satellites





Objective and Outline

Objective: Compile a Cohesive Ozone Profile data set, and
Apply Hockey-Stick trend analysis

Outlines:

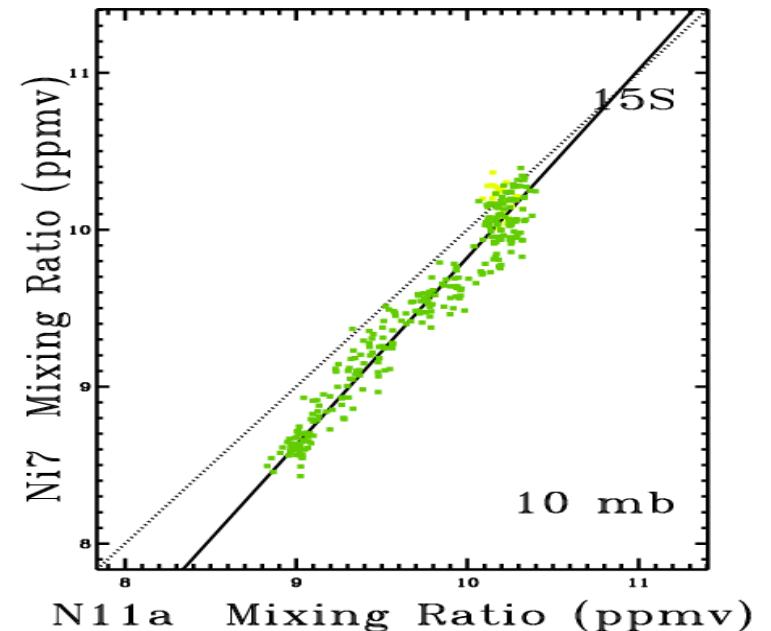
- The Methodology
- Comparison with SAGEII & Lidar
- Preliminary Trend Analysis
- Summary & Future works

Product

- A SBUV/(2) only data set
- Combines data from Nimbus 7, NOAA 9, NOAA 11, NOAA 16 and NOAA 17
- Extends from 1978 to 2009 (soon to add 2010)
- Daily zonal averages centered on 5 degree bins (0, +/- 5, +/- 10 ...) from 80S to 80N
- Two products: mixing ratio on pressure level and layer data

Methodology

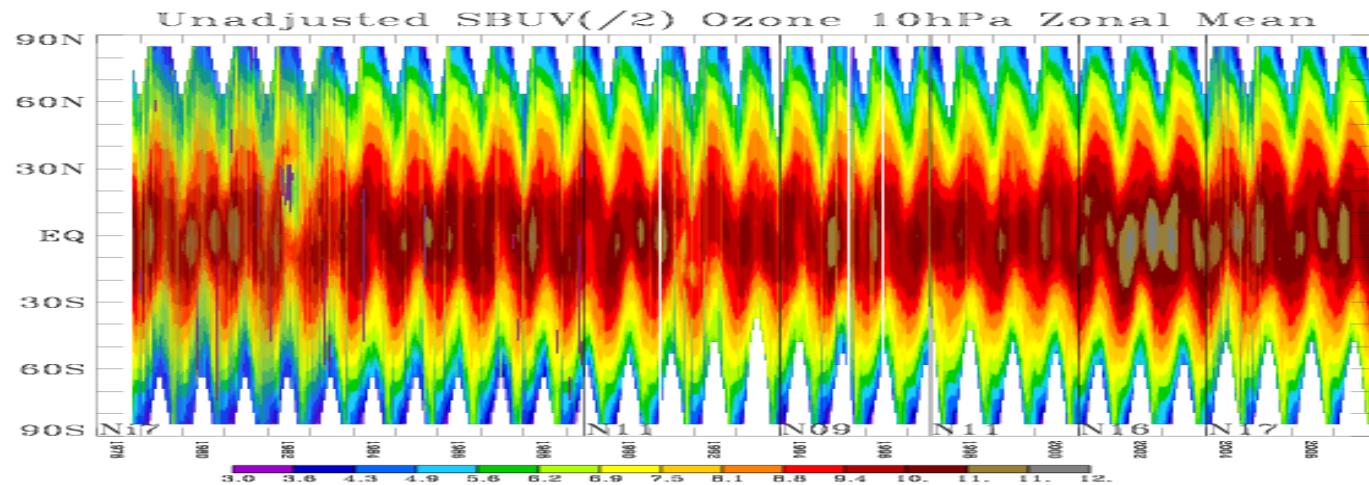
- Constructs correlation graph of data from two instruments in a overlap period
- A different adjustment is determined for each latitude and level/layer
- Effectively adjusts bias and annual amplitude
- When correlation coefficient is below .9 a bias only adjustment is made



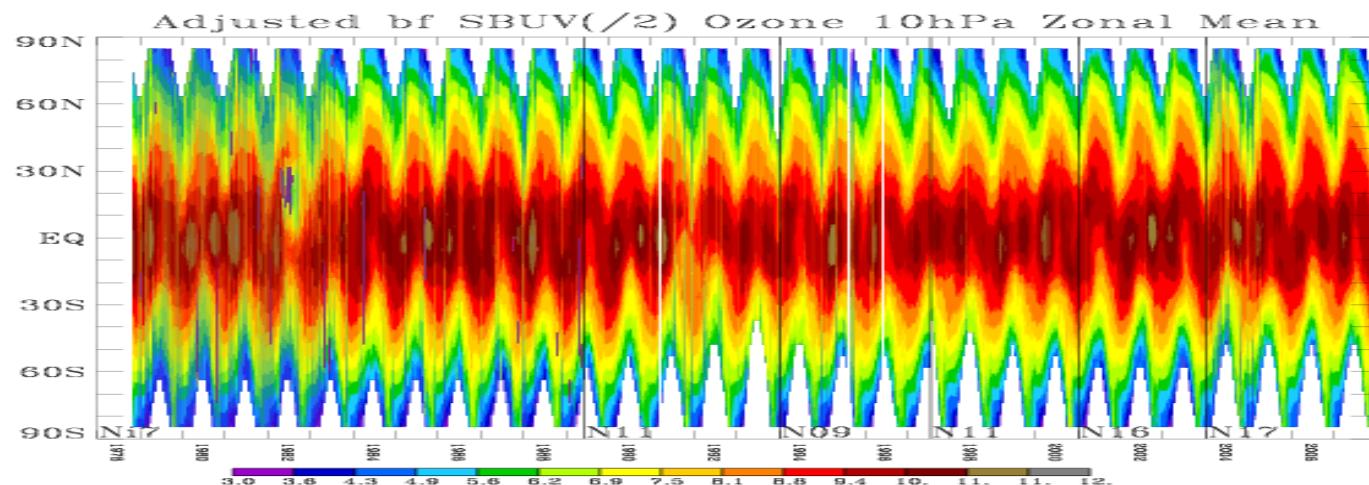
Overlapping datasets

Transition	Satellite 1	Satellite 2	Overlap Dates	Overlap method
1	Nimbus 7	NOAA 11a	12/1/88 – 10/31/89	Slope and Intercept of Correlation
2	NOAA 11a	NOAA 09d	7/1/93 – 6/31/94	Slope and Intercept of Correlation
3a	NOAA 14	NOAA 11d	Various	Bias *
3b	NOAA 09d	NOAA 14	Various	Bias *
4	NOAA 11d	NOAA 16	10/3/00 – 3/27/01	Bias
5	NOAA 16	NOAA 17	7/11/02 – 12/31/05	Slope and Intercept of Correlation

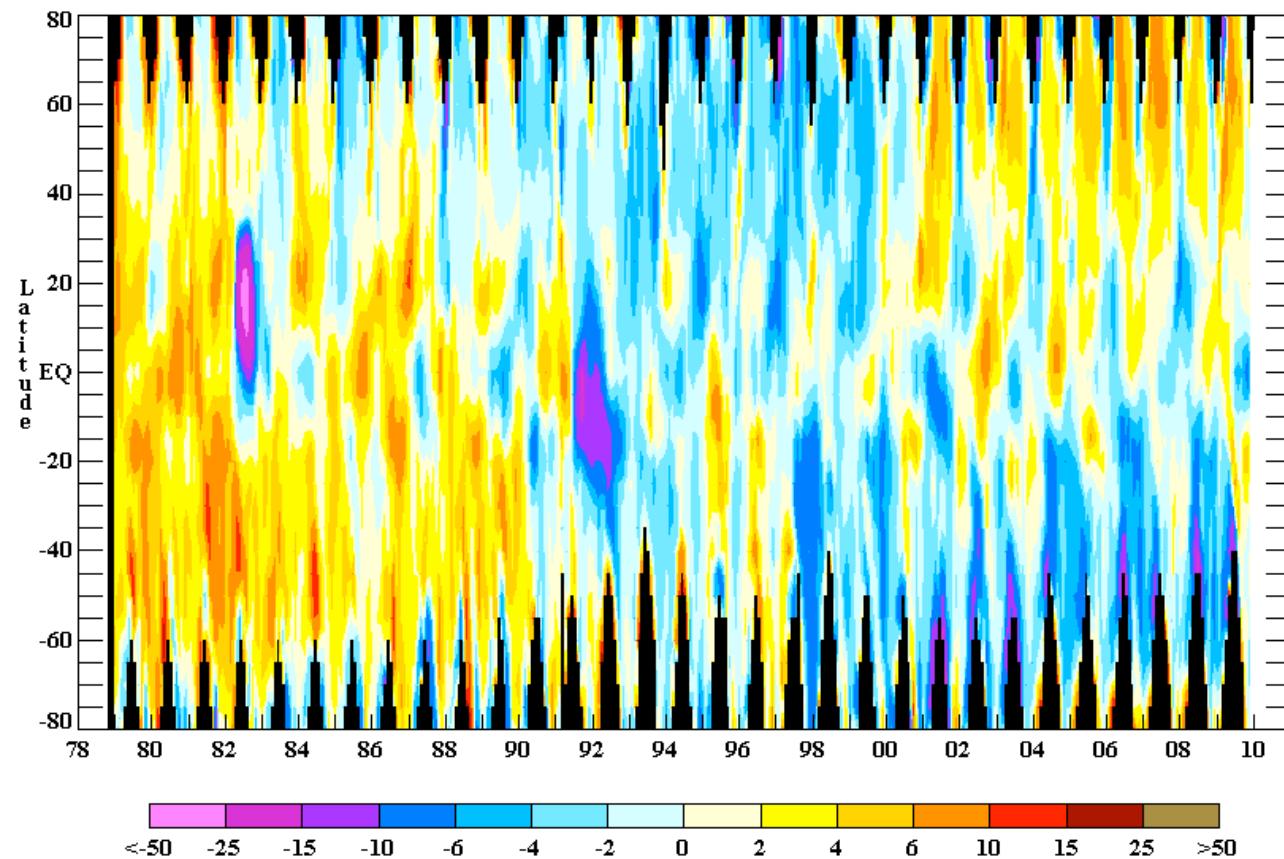
Contour of 10mb shows discontinuity at NOAA 11 to NOAA 16 transition



Contour of adjusted plot shows that the NOAA 11 to NOAA 16 bias at the equator is eliminated.

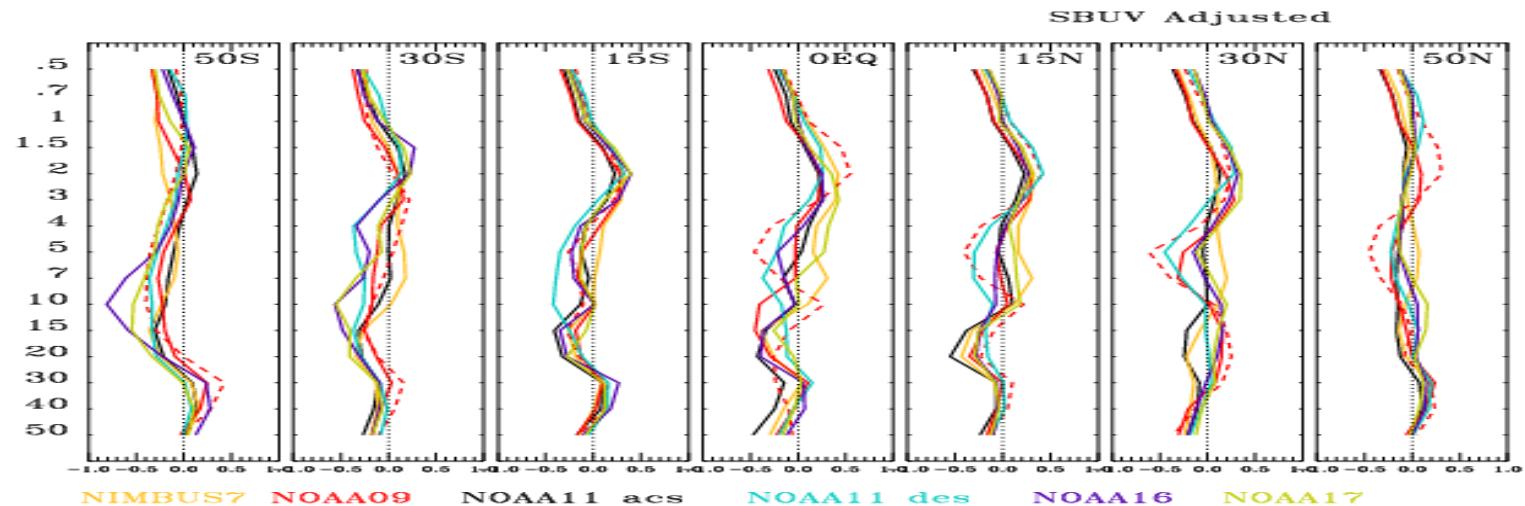
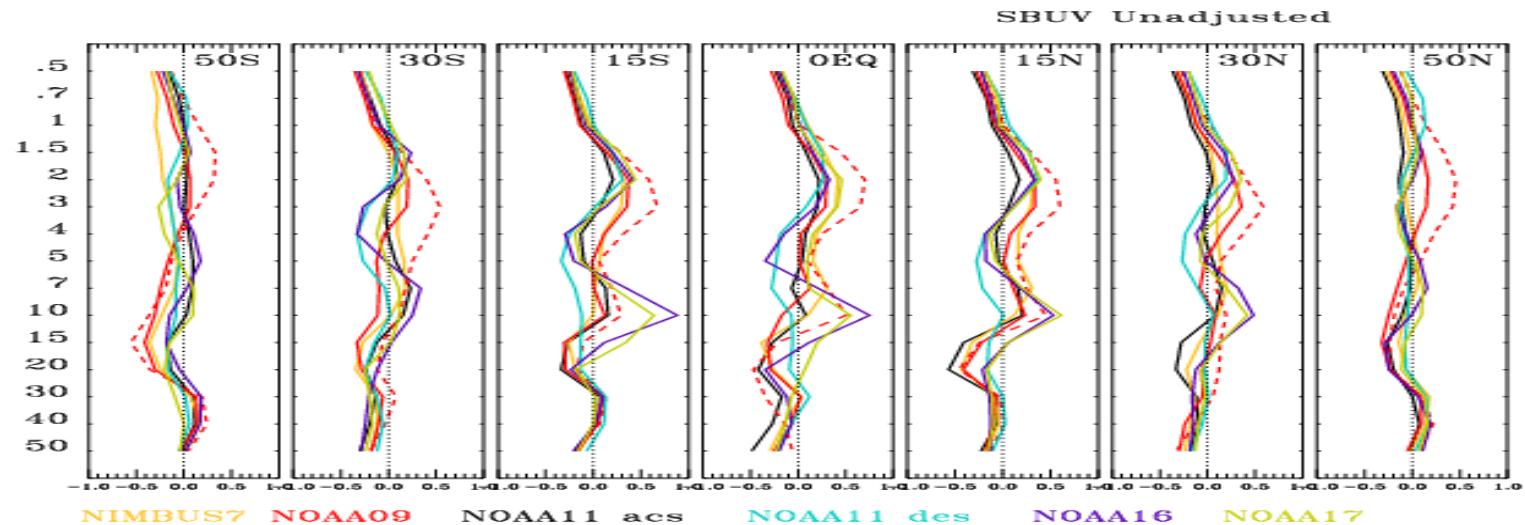


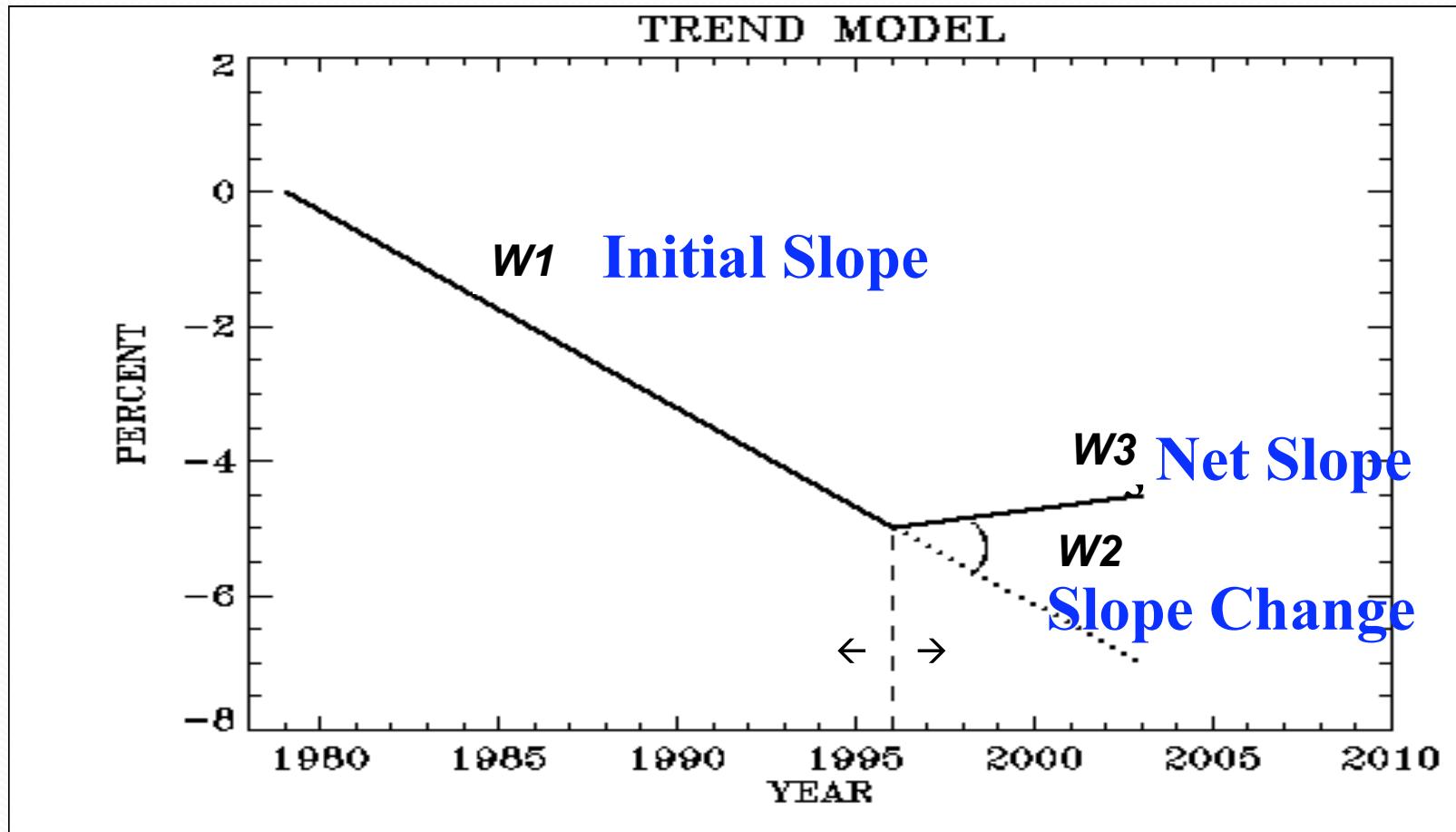
SBUV&SBUV/2 10 hPa COHESIVE PROFILE OZONE ANOMALIES (PCT)



Comparisons to SAGE II

Adjusted biases more consistent from satellite to satellite.





Hockey stick trend model showing an initial slope (W_1) to an inflection point set here to 1996, followed by a slope change (W_2) resulting in a post inflection point net slope (W_3). Ozone recovery is implied if the net slope is positive.

Linear Trend and Change-in-Trend Model

$$y_t = \sum_{i=1}^{12} \mu_{li} I_{i,t} + \beta_{l1} x_{t1} + \beta_{l2} x_{t2} + \delta_l AO_t + \gamma_l Solar_t + \lambda_l Intv_t + N_t$$

$$N_t = \phi N_{t-1} + e_t$$

where

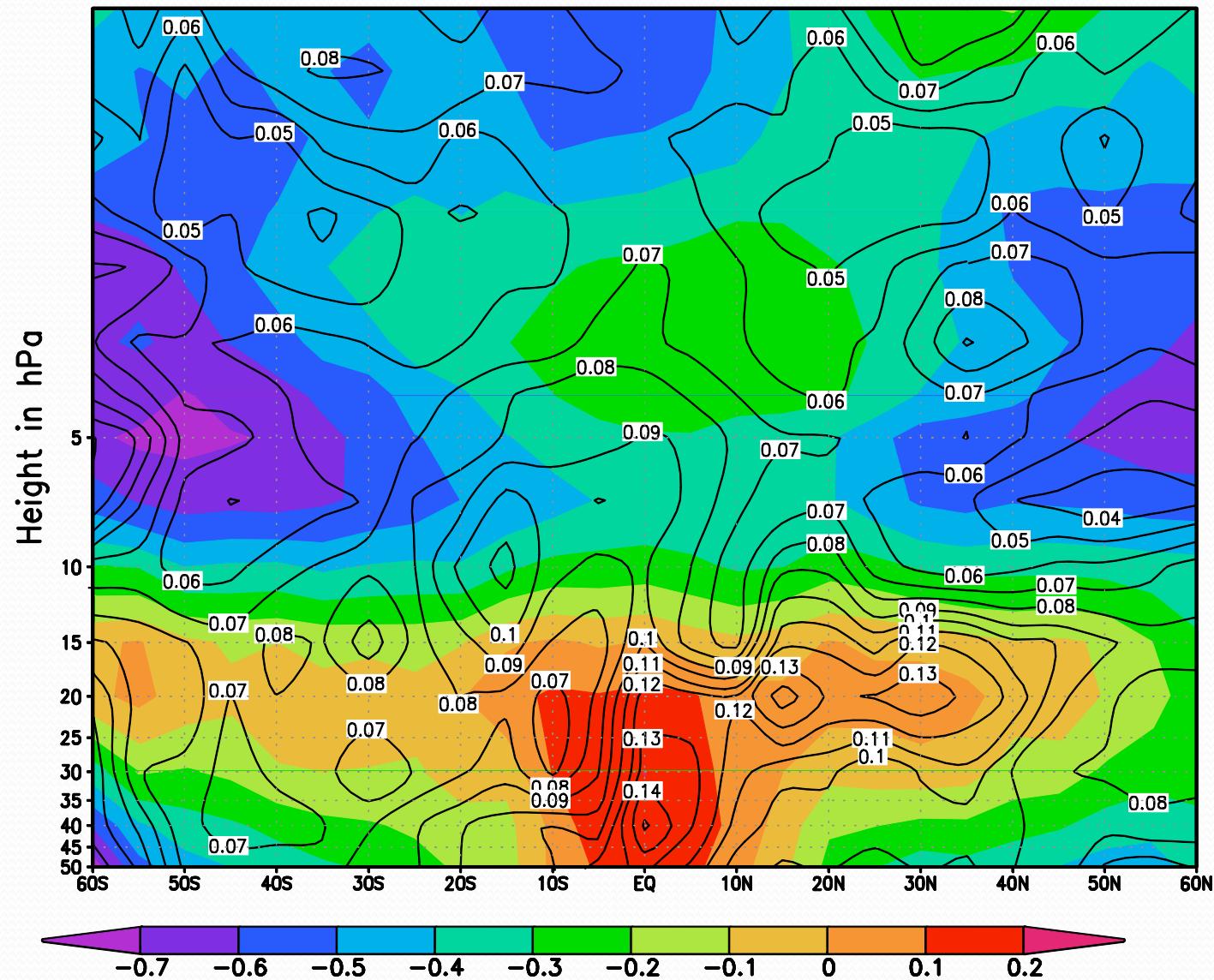
$$x_{t1} = \frac{(t - t_0)}{12}, \quad t_0 \text{ corresponds to Dec. 1969.}$$

$$x_{t2} = \begin{cases} 0 & t \leq t_* \\ \frac{(t - t_*)}{12} & t > t_* \end{cases}, \quad t_* \text{ corresponds to Dec. 1995.}$$

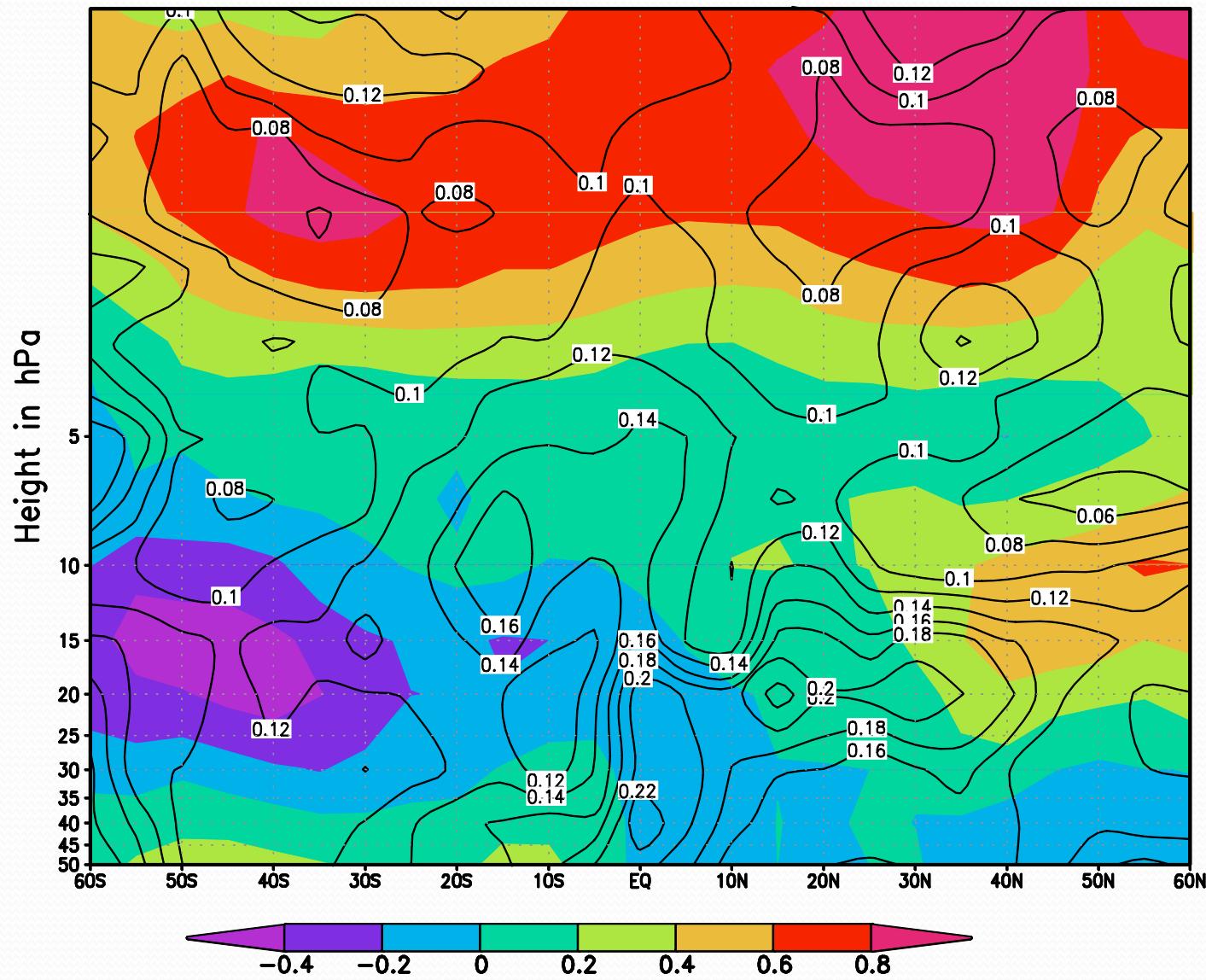
$I_{i,t}$'s are dummy variables.

e_t is an uncorrelated series with seasonal variances to account for different variability in different seasons.

trend 1979–1995



Preliminary Trend Analysis 1996~2009



Remark and Data Source

- In SH, there is no perceivable recovery of ozone, except at the top of the stratosphere. Between 10~30 hPa, there is continual depletion, versus the depletion above and below before 1996.

Data availability

- Soon be available on NOAA/CPC ftp sites:
www.cpc.ncep.noaa.gov/products/stratosphere/sbuv10

Future Works

Total Ozone comparisons

- Integrate the layer dataset and compare to the NOAA Cohesive Total Ozone dataset for consistency

Understanding Diurnal issues and the effects on the internal trends of satellites especially NOAA 9 and NOAA 11

- Use NDACC microwave data to model diurnal characteristics of ozone

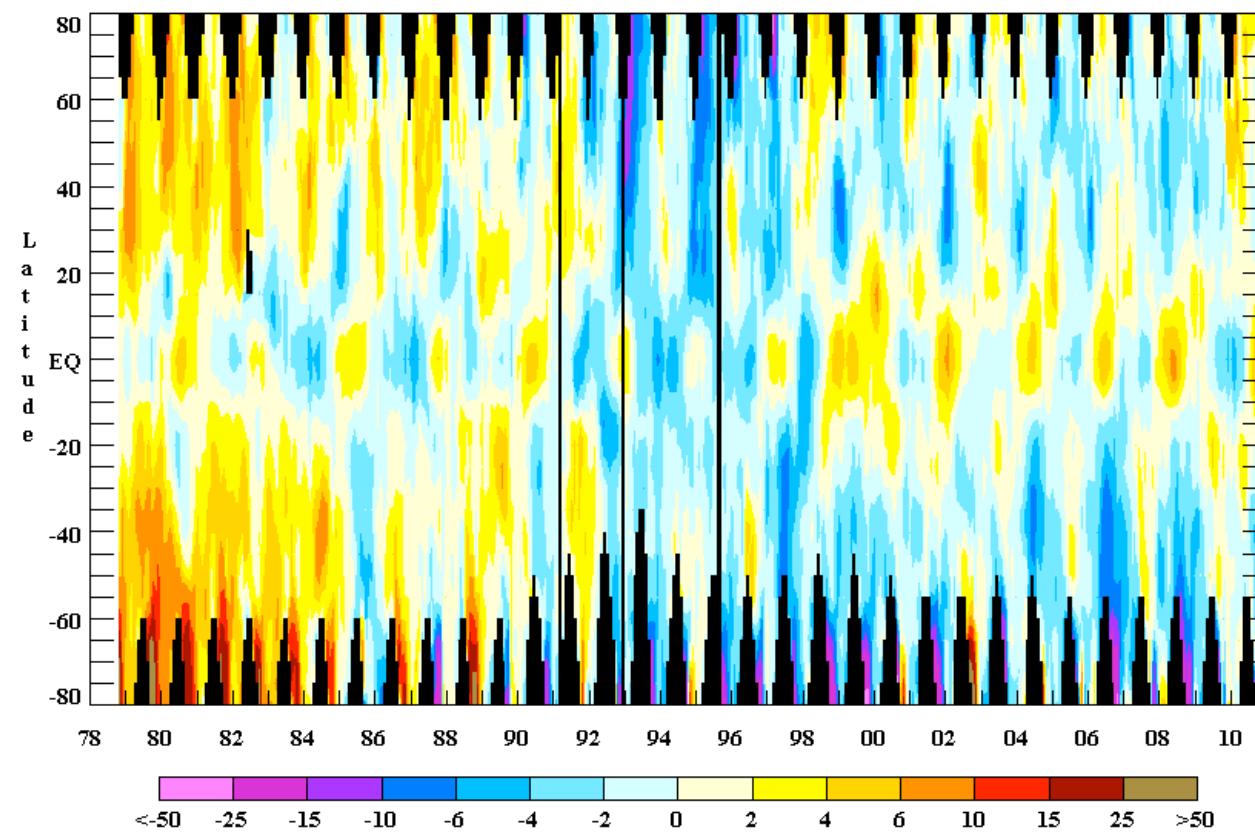


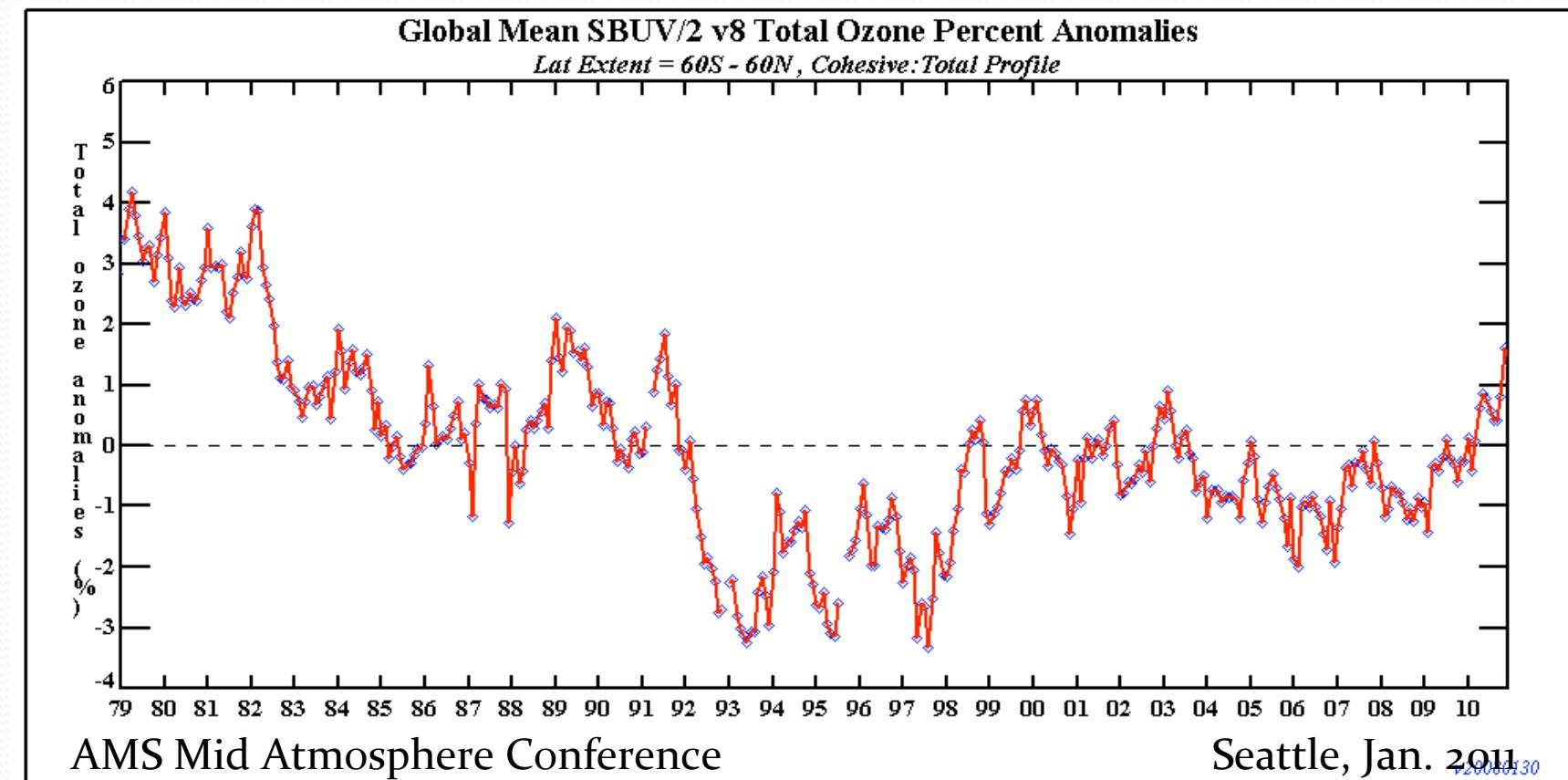
Back Up slides

Final Period Choices

Satellite	Satellite dates	Notes
Nimbus 7	10/31/78 – 5/31/89	
NOAA 11	6/1/89 – 12/31/93	Eliminates early noisy N11 data at high levels, Northern Mid-Latitudes. See 30N 1hPa.
NOAA 9	1/1/94 – 7/14/97	
NOAA 11	7/15/97 – 12/31/00	
NOAA 16	1/1/01 – 12/31/03	
NOAA 17	1/1/04 – 12/31/09	

SBUV&SBUV/2 COHESIVE TOTAL OZONE ANOMALIES (PCT)





Input Data

Satellite	Data Source	Version	Available Data	Record Length in Words	Flag
Nimbus 7	NOAA/NESDIS	8 *	10/31/78 – 6/21/90	500	0
NOAA 9	NOAA/NESDIS	8.0403	2/2/85 – 12/31/90	500	100
NOAA 9	NOAA/NESDIS	8.0403	1/1/91 – 2/19/98	500	110
NOAA 11	NOAA/NESDIS	8.1506	12/01/88 – 3/31/95	500	0
NOAA 11	NOAA/NESDIS	8.1506	7/15/97 – 3/27/01	500	10 or 110
NOAA 14	NOAA/NESDIS	8 **	2/5/95 – 8/31/04	500	0 or 3
NOAA 16	NOAA/NESDIS	8.1822	10/3/00 –	2000	0 or 100
NOAA 17	NOAA/NESDIS	8.1619	7/11/02 –	2000	10
NOAA 18	NOAA/NESDIS	8.2014	6/4/05 –	2000	0

Special cases

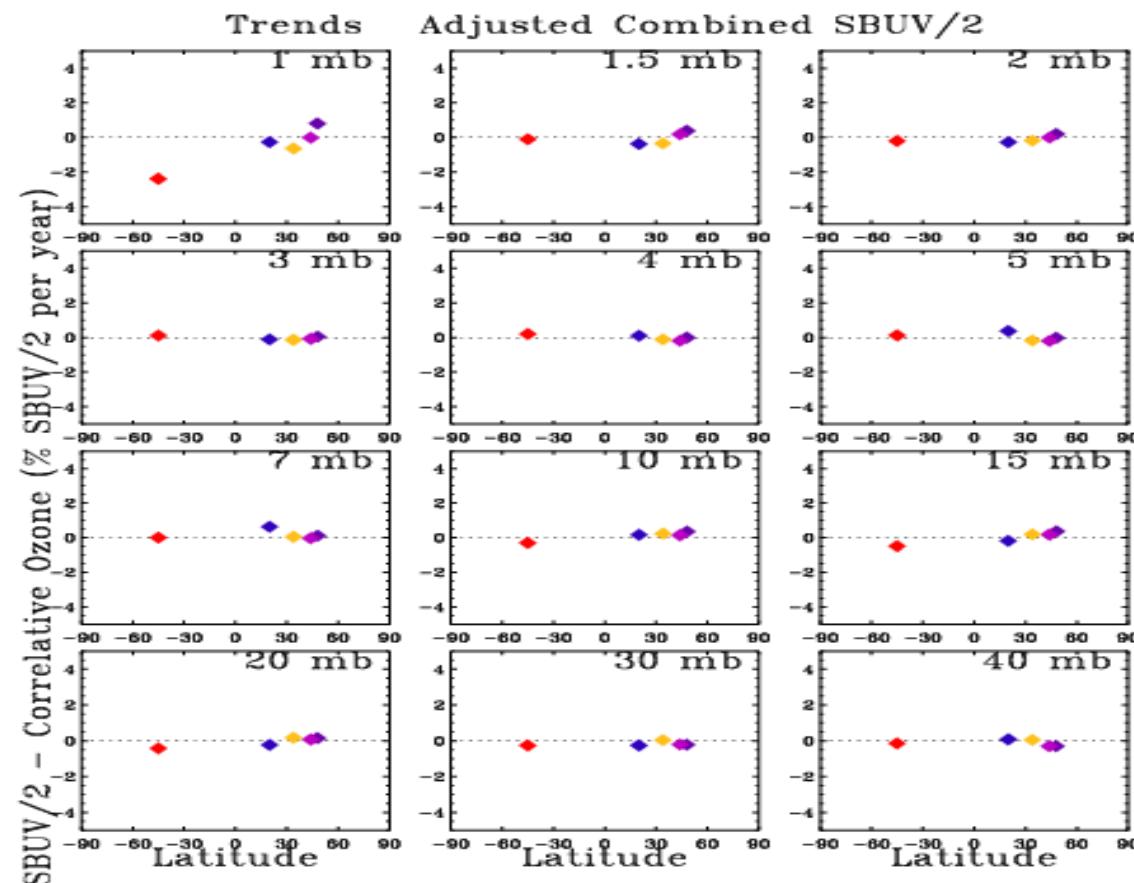
NOAA 16 Adjustment

- bias only due to short overlap period

NOAA 11 Descending Adjustment

- There is no viable overlap between NOAA 9 Descending and NOAA 11 Descending in 1997 since NOAA 9 is substantially degraded when NOAA 11 is again available
- At some levels the portion of NOAA 9 after June 1996 is offset from the rest of the data, ex: 15S at 3 hPa.
- NOAA 9 Descending has known trends
- We choose to use adjust NOAA 11 Descending with the same adjustment as NOAA 11 Ascending to avoid the retention of NOAA 9 deficits

Differences of the Trends wrt NDACC data



trend change at Jan 1996

